Simba's Sunny Day

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Introduction

Heat stroke is a complex disease process, which if severe, can result in multi-organ dysfunction syndrome (MODS) and death. Two types of heat stroke are commonly described in the canine patients. Classical heat stroke describes a passive rise in ambient temperature which outpaces the animal's ability to use cooling mechanisms (such as being locked in a hot car). Exertional heat stroke is a more active mechanism: as an animal runs or otherwise expands energy, the heat produced overwhelms the ability of that animal to dissipate it. As ambient temperature rises past 86F, canine body temperatures also begin to rise. Cooling mechanisms such as panting and hypersalivation are initiated; however, in areas where humidity is greater than 80%, evaporative cooling can no longer efficiently disperse heat.[6] When the body temperature exceeds 104F, breakdown of the animal's ability to equilibrate temperature begins.[6] At 105F, with concurrent central nervous system dysfunction, formal heat stroke is diagnosed.[2] At 106F, cerebral edema begins and permanent neurological damage may occur.[6] Additional common sequelae from this rise in temperature are disseminated intravascular coagulation, systemic inflammatory response syndrome, and multi-organ dysfunction syndrome. Although virtually any organ in the body is susceptible from damage, severe vascular disorders, kidney injury, and hepatic dysfunction are of primary concern. [6]

Predisposing factors for heatstroke include brachycephalic upper airway syndrome, obesity, lack of water, and dogs on either end of the age spectrum. Young and old dogs more prone to heat stroke due to a decreased ability to tolerate heat. [6] Dogs who are not acclimated to a warm environment and are transposed from a colder area are also more likely to suffer from heat stroke than those who have been in the warm temperatures longer. Higher mortality rates are seen in older dogs, more severe heat exposure (higher rectal temperatures at presentation

implying a higher maximal temperature achieved), and longer time spans between initial thermal insult and presentation at a veterinarian's office. [1] Mortality rates from heat stroke can easily exceed 50% of severe cases.[2]

History and Presentation

Simba is an approximately 7 year old male neutered Cavalier King Charles Spaniel who presented to the Mississippi State University College of Veterinary Medicine (MSU-CVM) Small Animal Emergency Service on June 12, 2018 as a referral for management of severe heatstroke. Simba's owners had been out of the country for approximately one week and in their absence had hired help to care for their home and animals. On the morning of June 12, Simba was let outside and remained there without water and with minimal shade. Around 11am, Simba was discovered in the backyard recumbent, comatose, and surrounded by vomit and hemorrhagic diarrhea. His owners were contacted and Simba was immediately taken to his referring veterinarian. At the veterinarian's office, Simba's temperature was too high for the thermometer read. A neurological examination revealed absent pupillary light reflexes and absent menaces bilaterally. His oxygenation status was decreased with a SpO2 of 88%. Simba was administered one liter of intravenous lactated Ringer's solution and active cooling was initiated. Bloodwork was performed which revealed a mild hyperglycemia and mild hyperbilirubinemia. After an hour of cooling, Simba's temperature was reduced into the readable range and was measured at 110 F.. Simba was then referred to MSU-CVM for further care. While being transported from his referring veterinarian, Simba aspirated vomitus.

Upon presentation to the MSU-CVM Emergency service, Simba was mentally inappropriate and unaware of his surroundings. He weighed 12.6 kg with a body condition score of 8/9 (5/9 being ideal). He was tachycardic (HR: 160 bpm), with a normal respiratory rate and

temperature (T: 101.7F, RR: 36 brpm). His respiratory effort was increased. His pupillary light reflexes were intact bilaterally, but his menace response was bilaterally absent. Cardiac auscultation was normal, but careful evaluation was hindered due to increased bronchovesicular lung sounds in all fields. Simba's mucous membranes were hyperemic and tacky, and he was estimated to be 10-12% dehydrated. Multifocal petechial hemorrhage was present along his gingiva and ventrum. The remainder of his physical examination was unremarkable.

Pathophysiology

The pathogenesis of heat stroke has multiple mechanisms: direct thermal insult of the body, in addition to damage related to the associated inflammatory mediators. In order for thermal injury to occur, the rise in body temperature must outpace the ability of compensory mechanisms responsible for dissipating heat. Temperature is regulated centrally by the caudal hypothalamus, with sensory input coming from the skin, viscera, and central nervous system.[6] Once a rise in temperature is detected by the body, peripheral vasodilation, central vasoconstriction, and splenic contraction occurs. These processes combine to shunt blood to the skin in order to increase heat dissipation. [1] As internal temperature continues to rise, panting is initiated as the primary heat dispersal method. Air flows through the nasal turbinates and out through the mouth, using the increased surface area of the turbinates as a counter-current exchange system for dissipating heat..[6] However, the efficacy of these mechanisms is still dependent upon both ambient temperature and speed of internal heating. As external temperatures rise, these eventually fail to reduce heat efficiently enough to outpace heat production.[6] In addition the mechanisms utilized to produce cooling, result in heat production from energy expenditure.

As internal temperature rises, clinical signs develop rapidly. As the hyperthermia progresses, the cutaneous blood pooling results in a decreased circulating volume. This is combined with nitric oxide buildup in the spleen, producing concurrent splanchnic dilation and subsequent cardiovascular collapse, ischemia, hypoxia, and shock. Temperature increase also leads to direct thermal damage of the body and activation of inflammatory and hemostatic cascades. Thermal damage to the muscle may trigger rhabdomyolysis which in turn leads to kidney damage (already affected by decreased bloodflow and hypoxia)[1,5] Inflammatory disruption of hemostatic cascades and endothelial insult results in injured endothelium releasing a myriad of mediators including thromboplastin, kinines, kalikrein, and factor XII. This activates the intrinsic coagulation pathway and complement system, leading to hypercoagulability, disseminated microthrombi, and disseminated intravascular coagulation. Neurological signs are seen due to cerebral hypoperfusion, vascular insult, cerebral edema, and coagulopathy. Depending on the severity of cerebral edema clinical signs may range from changes in mentation to more severe clinical signs such as respiratory arrest.[6] Inflammatory cytokines trigger systemic inflammatory response syndrome and lead to multiple organ dysfunction[3]

Acute respiratory distress syndrome may develop. Acute lung injury in these cases is a result of both thermal and biochemical mechanisms, with the end result being noncardiogenic pulmonary edema inhibiting normal respiratory function. Infarction due to hypercoagulability and alveolar hemorrhage is also possible.[1] Finally, gastrointestinal signs are also frequently present. Intestinal insult is due to shunting of blood away from the gastrointestinal tract as it is directed to the skin for cooling. As a result the endothelial barrier between the lumen of the gastrointestinal tract and circulation breaks down. This can result in bacterial translocation.[1]

Diagnostic Approach

A triage examination was performed and revealed a decreased oxygenating ability (Sp02 88%), and ECG revealed a sinus tachycardia. Thoracic FAST scan revealed pulmonary consolidation bilaterally, and abdominal FAST scan was within normal limits. Blood was drawn for a CBC, serum chemistry, lactate and clotting times. The CBC revealed a mild thrombocytopenia (96,000/μL) and occasional megaplatelets. The CBC also revealed a nucleated red blood cell count of 41/100 leukocytes. A recent publication revealed that the relative and absolute numbers of peripheral NRBCs in headstroke patients are prognostic, and correlate with risk of death and secondary complications. A cut off point of 18 NRBC/100 leukocytes corresponds to a sensitivity and specificity of 91% and 88% respectively for death. [8] The serum chemistry revealed a mild azotemia, mild elevations in both ALP and ALT, a markedly elevated CK, in addition to electrolyte abnormalities. PT was mildly elevated at 12.1s. PTT was within normal limits at presentation. The patient was diagnosed with severe heatstroke, based on the history, clinical signs and bloodwork abnormalities detected.

Treatment and Management

When treating heat stroke, active cooling should be initiated as soon as possible, even before presenting to a veterinarian. Cool, but not cold, water should be utilized on the ventrum and inguinal regions to lower body temperature. Rectal temperature should be taken regularly to evaluate core body temperature. Fans may be placed on the patient to help safely reduce temperature. Cold water enemas and gastric lavage have also been reportedly used in cooling; however, these techniques may be associated with increased incidence of aspiration pneumonia and gastrointestinal permeability, and are generally not recommended. Once the patient reaches 103F, active cooling should be stopped in order to avoid development of hypothermia.[4]

Fluid resuscitation is critical and should be instituted during active cooling to treat shock and rapidly restore perfusion. Balanced electrolyte solutions are frequently the first reached for and administered in small, repeated boluses.[4] Fluid diuresis should continue after initial volume resuscitation to protect the kidney from further damage and possible rhabdomyolysis. Once the patient is stable, glucose may need to be added to the fluids as a result of increased consumption and decreased production due to liver dysfunction. Serial blood glucose readings should be taken to monitor for severe hypoglycemia. Mannitol may need to be administered depending on the severity of cerebral edema and associated clinical signs.[4] If coagulopathy is detected, administration of fresh frozen plasma is indicated. Whole blood transfusions may be preferable in cases where bleeding is severe and packed cell volume is quickly reduced.

The remainder of supportive care depends on the specific clinical signs of the individual patient, as any combination of organs may be affected by thermal injury, shock, SIRS, and microthrombi. Gastroprotectants and antibiotics are typically indicated to prevent infection and sepsis as a result of breakdown of the gastrointestinal lining.[4] Anti-emetics and appetite stimulants may present some use as the patient recovers. Oxygen therapy may be necessary depending on the level of lung injury.

Prevention of heat stroke is infinitely preferable to treating. Acclimation to warm temperatures and availability of shade and water is critical for prevention. A properly acclimated dog who has spent extensive time in a warm area is more likely to tolerate higher temperatures than its counterpart who has recently arrived from a cold area.[1]

Case summary and outcome

The emergency service gave Simba a fresh frozen plasma transfusion. Simba was hospitalized in an oxygen cage and was given supportive medical care consisting of IV fluid therapy, analgesia, maropitant citrate and pantoprazole. Simba was monitored closely throughout the night. Simba demonstrated evidence a Cushing's reflex, and was given mannitol intravenously. As the night progressed, Simba's heart rate decreased further (to 60 bpm) with systolic pressures greater than 200 mmHg and he was administered a 5 mL/kg dose of hypertonic saline IV. His mental status improved over the course of the night. However, his petechiation and respiratory effort continued to worsen throughout the night. Repeat clotting times were performed after the transfusion, and the PT/PTT were at the high end of the reference interval. A repeat ECG revealed occasional lone P waves, dropped beats, and premature ventricular contractions. On the morning of June 13, 2018, Simba was transferred to MSU-CVM's Internal Medicine Service for further treatment.

After transfer, thoracic radiographs were performed and revealed aspiration pneumonia, mild left atrial enlargement, and suspect acute lung injury. Repeat bloodwork was performed and Simba's clotting times were markedly elevated (PT/PTT: >120.0/>235.0). A repeat fresh frozen plasma transfusion was given. Following the transfusion, the clotting times had improved, but were still elevated. A third plasma transfusion was given, and the clotting times were normal for the next 3 days. Simba continued to have marked respiratory difficulty and was provided with antimicrobial coverage and oxygen supplementation. Simba was markedly weak and continued to demonstrate neurological abnormalities. Simba had marked hemorrhagic diarrhea. Over the next several days, serial coagulation panels, CBCs, chemistries, and thoracic radiographs were performed along with complete physical examinations to monitor Simba's progress.

During the first few days of treatment, Simba's bronchovesicular sounds worsened and crackles developed. Serial thoracic radiographs revealed worsening aspiration pneumonia and signs of acute lung injury. Simba consistently had mildly elevated temperatures of approximately 103F. As a result, Simba's antibiotic combination was changed from Unasyn and metronidazole to cefoxitin and metronidazole. Once the switch was made, Simba's temperature normalized. Simba's hemorrhagic diarrhea became melena and slowly improved over the course of his stay.

As Simba's respiratory rate, effort, and SpO2 improved, he was slowly weaned off oxygen supplementation. On June 18, after six days of therapy, Simba acutely developed horizontal nystagmus, tremors, and a rapidly elevating temperature (3 degrees in approximately 10 minutes), after metronidazole administration. He was administered diphenhydramine and after approximately 30 minutes, his symptoms resolved. Simba's metronidazole was discontinued and although he never regained his menace response, he remained otherwise neurologically normal for the remainder of his stay. Due to breed predilection, Simba's neck pain was presumptively diagnosed as chiari-like malformation and further workup was declined by his owner.

On June 20, Simba was discharged to his owner's care with antibiotics, Cerenia, mirtazapine, and sucralfate. Recheck examination were performed at his referring veterinarian's office and a cardiac workup at MSU-CVM was recommended for Simba's enlarged left atrium. At the time of discharge, he had been presumptively diagnosed with mitral valve insufficiency based off of breed predilection, but further workup was declined by his owners. As of October 28, 2018, Simba has been doing excellent at home having made a full recovery with no further abnormalities.

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